

The Demand for Environmental Quality in Driving Transitions to Low-Polluting Energy Sources

Roger Fouquet

London School of Economics; Basque Centre for Climate Change (BC3);
IKERBASQUE (Basque Foundation for Science). Email: r.fouquet@lse.ac.uk.

Abstract

The purpose of this paper is to understand the long run demand for energy-related environmental quality, its influence on legislation and on transitions to low polluting energy sources. It presents a series of episodes in British history where a demand for improvements in energy-related environmental quality existed. These episodes helped to identify a few cases where markets partially drove transitions to low polluting energy sources, in specific economic conditions. More generally, they showed that, when pushed, governments will introduce environmental legislation, although it tends to be weak and poorly enforced. In the case of air pollution, strong and binding legislation occurred roughly one hundred years later than was socially optimal. Based on this evidence, for a transition to a low carbon economy, governments will probably need to introduce focussed and binding legislation, and this cannot be expected without strong and sustained demand for climate stability. This demand will need to be spearheaded by pressure groups to introduce legislation, to enforce it and to avoid it being over-turned by future governments.

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1. Introduction

A transition to a low carbon economy is seen as a possible solution to meeting the demand for climate stability (Grubb et al. 2008, Foxon et al. 2008). Given policy-makers' interest in transitions from the existing fossil fuel-dominated energy system, it might be valuable to identify how past energy transitions have evolved. These may offer insights that are relevant for how to or how not to aid a desired transition.

While a number of studies have investigated historical energy transitions (Schurr and Netschert 1960, Cipolla 1962, Humphrey and Stanislaw 1979, Fouquet and Pearson 1998, Grübler 2004, Gales et al. 2007, Bartoletto and Rubio 2008, Kunnas and Myllyntaus 2009), offering a rich understanding of their nature and implications, fewer have explored the drivers of these transitions. Smil (2010) emphasized the key role new technologies played in generating past energy transitions. Grübler et al (1999) identified that technological innovations depend on achieving economies of scale in production. Geels (2002) showed how the co-evolution of technologies, industries and institutions enabled new energy sources to emerge. Madureira (2008) highlighted the role played by resource endowments and government objectives. Allen (2012) stressed the importance of prices in driving energy transitions.

The conclusion from a review of fourteen past experiences was that any future transition seems likely to occur only if the new combination of energy sources and technologies provides cheaper services (Fouquet 2010). In addition, a transition to a low carbon economy might require a qualitative change in the energy sources. In a number of past cases, the substitution enabled qualitative changes in the nature of the

service provided, and niches of consumers were willing to pay more for the associated additional value. However, the additional value was associated with private benefits.

Most of the benefits of a consumer buying low carbon energy sources will be passed on to society as a whole, rather than generating large private gains. So, voluntary efforts to reduce emissions by using low polluting (i.e. higher value) but more expensive energy sources are likely to be hampered by the tendency for many consumers to free-ride.

Nevertheless, society and individuals appear to value reductions in carbon dioxide emissions and a transition to low carbon energy sources (Brouwer et al 2008, Lee and Cameron 2008, Mackerron et al 2009, Löschel 2010, Diedrich and Goeschl 2011). Given this demand for climate stability and a social benefit from a transition to low carbon energy sources, yet a tendency to free-ride, it is important to improve our understanding of how this demand might be met and such a transition might be achieved.

The purpose of this paper is to focus-in on past experiences to identify the factors that enabled the demand for environmental quality to become eventually translated into environmental legislation, and the factors that led a transition to a low polluting energy source to become a key part of the legislation to meet this demand. To do so, it reviews five episodes from British history of the demand for energy-related environmental quality and whether it could be or was met by low polluting energy sources.

The next section discusses the concept of the demand for environmental quality and how that demand changes through time. The next five sections review five historical cases (seventeenth century, nineteenth century, and early-, mid- and late-twentieth century) of a demand for energy-related environmental improvements and of the market and government reactions to this demand. Section eight discusses some insights from these experiences for a possible transition to a low carbon economy. The final section draws conclusions.

2. The Demand for Environmental Quality

Throughout history, and as will be discussed later, energy consumption has been responsible for a great deal of health and environmental damage. Some, observing these external costs and recording their scale, have demanded improvements in environmental quality (Brimblecombe 1987).

At a particular level of pollution, the higher are the marginal external costs or equivalently the marginal benefits of abatement, the more we might expect individuals to be willing to pay for improvements in environmental quality or willing to seek them by other means, such as lobbying for legislation.

The marginal benefits of pollution abatement have two components, the physical impact or damage from pollution exposure and the individual or group's valuation of that damage. One might expect the impact of a pollutant on a person's health of the same age and with similar physical characteristics to be the same whether in the nineteenth, twentieth or twenty-first centuries. The marginal benefits of abatement

might change, however, for demographic or physical reasons. Yet, much of the variation in demand for environmental quality between periods will be associated with changes in the perceived marginal benefits of abatement.

First, as income rises, households have more time and money to be concerned about the environment – that is, there is a ‘positive’ and growing income elasticity for environmental quality. Second, although there is limited evidence of this, as incomes rise, households may be more than proportionately concerned and interested in the environment – a ‘greater than one’ income elasticity for environmental quality (Dorfman 1977). In fact, there is evidence that in certain cases, income elasticities for environmental quality are relatively low (Kristrom and Riera 1996, McConnell 1997). However, it does appear that when an economy is in a recession, environmental concerns decline, as economic and other social issues take priority. Thus, in the short run, demand might be quite unstable, shifting with the business cycle.

Third, a factor that might account for income elasticities that rise with income is that higher incomes are often associated with higher levels of education and access to information and knowledge of environmental pollution, risks and hazards. This often drives the introduction of more stringent environmental legislation (Dasgupta et al 2002, Kahn 2002). Fourth, Brasington and Hite (2005) examined the relationship between the price of housing and environmental quality, and found that price elasticity is relatively small, and propose that this result indicates either that people are not very sensitive to changes in the price of environmental quality or they cannot easily respond to changes in environmental quality, which depend on public decisions or moving. That is, moving neighbourhood is an expensive decision with major

implications for households, which they undertake infrequently, thus, markets are relatively rigid. Fifth, more open and democratic political systems should be more willing to reflect the concerns and sufferings of the public (López and Mitra 2000).

In general, since most of the costs of pollution are incurred by society (as damage to health, natural ecosystems, etc.) rather than the individual producer or consumer, they have tended to ignore these external costs when deciding how much energy to produce or consume. The consequence is that the demand for and supply of energy (or other goods) generating unpriced and/or unregulated negative externalities has tended to be higher than the socially optimal level. From an environmental perspective, improvements in environmental quality are a broadly (non-rival, non-excludable) public good, such that a socially insufficient level of environment quality tends to be provided (Buchanan 1968). That is, the demand (i.e., the willingness to pay for improvements or the marginal benefits of abating pollution) is greater than the marginal costs of abatement, implying society would ideally be better-off with a lower level of pollution (Oates and Cropper 1992).

When external costs of pollution are insufficiently recognized, the demand for environmental quality may find an outlet via demands for environmental legislation to regulate and ‘internalise’ the externality. The combination of legislation and the threat of enforcement might create incentives for polluters to reduce their emissions, and improve environmental quality towards the optimal level.

While the public may value improvements in environmental quality and be putting considerable pressure on politicians, there exist many factors that may lead to

government failure, such that environmental pollution remains either unregulated or sub-optimally regulated. First, other pressure groups may sway decisions away from these socially desirable improvements (Fernandez and Rodrik 1991, Dijkstra 1999). Second, the costs and complexity of producing, distributing and assessing scientific or other information, including information on people's willingness to pay for environmental quality, can hinder regulators' ability to identify appropriate levels of environmental quality (Brunner and Klein 1999). Third, bureaucracy may also limit the socially efficient decision-making of government (Breton and Wintrobe 1975, Oates and Strassman 1978).

A proper analysis of the demand for environmental quality and the way in which government addresses the demand would need to combine a number of different perspectives. In addition to a basic economic framework (Pearson 1994, McConnell 1997, Keohane et al. 1998, Kolstad 2006), this analysis of the environmental legislative processes needs to incorporate a political science framework for understanding the evolution of policy and legislation. It would consider the rigidities of political institutions and vested interests (Baumgartner and Jones 1993), the windows of opportunity for political change to be achieved, after disasters, for instances (Kingdon 1995), and the routes through which pressure groups drive their own agendas (Cobb et al. 1976). Unfortunately, due to space limitations, such a comprehensive framework is beyond the scope of this paper.

Instead, through reviewing five episodes in British history, this paper seeks to illustrate ways in which the demand for environmental quality in the form of reduced air pollution has influenced environmental legislation and transitions to low polluting

energy sources. The episodes occurred in the seventeenth century (Section 3), the Victorian era (Section 4), and the early- (Section 5), mid- (Section 6) and late-twentieth century (Section 7)). Section 8 explores insights relevant to meeting current demands for climate stability and Section 9 concludes the paper.

3. Fumifugium in the Seventeenth Century

In the seventeenth century, the economy and coal consumption in London had been growing rapidly (see Figure 1, and Broadberry et al. 2011). The transition from woodfuel to coal had begun in London in the sixteenth century as chimneys and grates were being introduced and refined, a reliable coal trade from the North-East of England developed, and the difference between the local price of coal and woodfuel increased (Fouquet 2011a, Allen 2012). The growing population and expanding economy of London created a rising demand for heating fuels, increasingly met by the coal trade.

This increase in coal combustion led to a growing air pollution problem in London, which was highlighted by a number of gentlemen associated with the Royal Society (Brimblecombe 1987). Most famously, John Evelyn, in his pamphlet *Fumifugium*, argued that the smoke associated with coal burning, particularly related to industry, was harmful to the population. Indeed, he points-out that, during the English Civil War (1642-46), the coal trade was severely disrupted, coal prices soared, and London air quality improved greatly (Evelyn 1661 p.21). He proposed that London should be redesigned, forcing polluting industries (such as brewers, dyers and lime-burners) to be based at sufficient distance from the population (Jenner 1995). Also, he mentioned

briefly that “if a law was passed for the planting and preservation of woods and forests, it would undeniably be possible to provide London with much greater quantities of wood, which would also reduce its price.” (Evelyn 1661 p.15).

Coal producers, merchants and consumers of the time were a heterogeneous group with little coordination. Also, scientific understanding was in its infancy and John Evelyn was a member of the Royal Society, the bastion of natural philosophy and the height of scientific enquiry of the time. He was able to meet with King Charles II to discuss the problem. Thus, building on previous scholars studies, he required relatively little proof to convince his colleagues and the King of the problem of air pollution. In January 1662, the Queen’s Attorney sent Evelyn the draft “of an Act, against the nuisance of the Smoke of Lond, to be reformed by removing severall Trades, which are the cause of it, and indanger the health of the K: and his people, etc. Which was to have ben offerd to Parliament, as his Majesty commended.” (Bowler 1981 p.109).

However, there is no evidence the Act was passed. Furthermore, following the Great Fire of London in 1666, and the rebuilding of London, there was little effort to reorganise the city in-line with Evelyn’s objectives or the proposed Act (Birmblecombe 1987 p.52). If it had been introduced, the legislation probably would have failed to dissuade producers given the advantages of coal over woodfuel in the capital. Inevitably, proposals to reduce pollution, as well as use more benign energy sources, were unsuccessful.

4. Air Pollution in Victorian Britain

4.1. The Demand for Air Quality in Victorian Britain

Later, in the mid-nineteenth century, after a further two hundred years of growth in the economy (Broadberry et al. 2011) and in coal consumption, air pollution in London was becoming far worse. The problem was immortalised in the stories of Sherlock Holmes. The Adventure of the Bruce-Partington Plans began “In the third week of November, in the year of 1895, a dense fog settled down upon London. From Monday to Thursday I doubt whether it was ever possible from our windows in Baker Street to see the loom of the opposite houses.” (Doyle 2003 p.412). When the fog descended, trains stopped running, court cases were abandoned, thieves prowled. The fog was coal smoke, which became trapped on windless days in the winter, when homes needed extensive heating, and the fog shielded the warmth from the sun. In the late nineteenth century, London averaged 80 days of dense fog per year! In parts of the city, such as West Norwood, in 1885, more than 180 days were recorded as foggy (Clay and Troesken 2010 p.62). The economic costs of lost output and trade to London, and other major cities, grinding to a halt due to the fog were consequently very substantial.

The rise in smoke concentration has also been linked with the rapidly soaring mortality rate attributed to bronchitis - from 25 deaths 100,000 inhabitants in 1840 to nearly 300 in 1890 (see Figure 2). A conservative estimate of the annual health damage caused by coal production and consumption at the end of the nineteenth century was £(2000)20 billion and close to 20% of the British GDP (Fouquet 2011b).

Despite the rapid rise, many commentators, possibly encouraged by industrialists fearing environmental legislation, questioned the harmfulness of air pollution. The miasma theory proposed that natural and biological decay caused impurities in the air, and smoke actually cleansed the air of these impurities. This argument only started to be formally rejected in the 1880s, and a consensus formed about the health damage caused by smoke (Thorsheim 2006 p.195).

The high levels of air pollution in Manchester, resulting in part from the concentration of coal-using cotton mills, led to the creation of the first Smoke Abatement Society in 1842. This and other of these voluntary organisations were off-shoots of wider movements seeking to improve environmental conditions and concerned about public health, bringing together women, middle-class professionals and non-conformist Protestants, partly driven by a belief that the lower classes needed to be cared for and their behaviour controlled (Thorsheim 2006 p.80). From the 1860s, the Smoke Abatement Societies in the major urban centres in Britain spearheaded the demand for improvements in air quality. “During the 1870s and 1880s [they] sponsored public lectures, classes, and publications that were intended to educate the public about the benefits of clean air and to promote gas cooking and heating appliances in place of coal fires.” (Thorsheim 2006 p.81).

The Smoke Abatement Societies across Britain tried to pressure successive governments into introducing legislation. They gained strength in the last couple of decades of the nineteenth century, when the damage done by air pollution was at its worst (see Figure 3), and their pressure mounted.

As early as the mid-nineteenth century, numerous solutions existed to help mitigate air pollution: businesses knew that good stoking was the key to both using coal efficiently and reducing smoke emissions (Thorsheim 2006 p.18); Continental and Scandinavian homes had used far more efficient stoves for heating at least since the eighteenth century (Fouquet 2008 p.79); gas cookers began being used in the 1840s, and there were extensive gas supplies in all towns across the country (Goodall 1999 pp.24-9) – although, as noted later, gas production from coal entailed a number of other pollution problems; there were other smokeless fuels, such as anthracite coal (available in the South West of Wales) and coke (produced by carbonising the coal first), that could have been used by households for heating purposes (Jevons 1865 p.156); and, railroads could have further expanded the limits of the city, spreading the air pollution and reducing concentration (Jackson 2003). So, opportunities for mitigation existed. The question was whether there was the political will to reduce emissions.

4.2. Legislation against Industrial Pollution

The political priority placed on growth in output and incomes meant that it was hard to deny firms the right to produce. A common approach to the pollution problem in the nineteenth century was containment. Rather than banning activities, they were tolerated where they already existed. This meant that polluting industries concentrated in particular areas, generally working-class areas, and ensured that middle-class suburbs and the countryside were relatively unharmed by industry's expansion. Those with higher incomes were able to move away from heavily polluted areas in towns and cities.

From the 1840s, a more interventionist approach began, if only sporadically. For instance, the Police Act introduced in Manchester led to the fining of thirteen cotton mills in 1845. However, they were only fined £2 each (Mosley 2001 p.144). Needless to say, such incentives failed to alter the behaviour of industry and it continued to pollute where it could. This example reflects the concern that imposing heavy fines would harm industry, reducing employment and competitiveness (both at a local and national level). This was the beginning of a very long process of balancing the desire to discourage polluting and the wish to avoid imposing excessive costs on economic activities.

In 1843, after extensive political struggle, a Parliamentary Select Committee on Smoke Prevention was formed. It was an acknowledgement of the national government's responsibility to address the problem. It was also one of the first uses of scientific expertise to inform government on the appropriate action. The problem was taken sufficiently seriously to draw upon the knowledge of Sir Thomas Henry De La Beche, Director of Geological Society, and Professor Lyon Playfair of the Royal Manchester Institute, and calling upon eminent scientists, such as Michael Faraday (Whitread 2011).

The Smoke Nuisance Abatement Act of 1853 introduced legislation to fine factories that emitted excessive smoke in London. During the first few years, the police were actively and aggressively involved in enforcing the law – with hundreds of cases. However, enforcement was inconsistent and the fines were very low – generally, less than one pound. Furthermore, with time, enforcement waned, and by the 1870s, the

law was ignored (Thorsheim 2006 p.112-3). More generally, many towns and cities across Britain were reluctant to take much action as many officials believed that punishing industry would drive manufacturers to less stringently regulated locations (Thorsheim 2006 p.119).

In 1863, following the setting up in 1862 of a Royal Commission to examine the problem of Alkali works, the Alkali Act, seen as the first national environmental legislation, was introduced. It was also innovative because manufacturers' activities, in particular, those of the chemical industry, were monitored by the authorities in order to minimise the damage done by hydrogen chloride to landowners, particularly large and wealthy ones. "A conjunction of circumstances favoured its passage[:] ... a practicable technology was available, most manufacturers were amenable to some control, and an effective lobby existed to push for legislation" (Dingle 1982 p.546). In this Act, a specific industry was addressed, and a condensation process was available, relatively cheaply, to capture almost all emissions. Using new scientific equipment developed for the purpose, it was possible to monitor effectively individual polluters and force them to reduce emissions (Dingle 1982). Thus, it was the first great success in British environmental legislation.

However, it failed to include emissions from coal combustion, despite strong efforts by prominent scientists (Thorsheim 2006 p.113). Finally, the Sanitary Act of 1866 required (rather than allowed) municipal officials to prosecute owners of smoky businesses. Industrialists considered that legislation restricting emissions would impose unacceptable costs, and fought to defeat such parliamentary bills and to minimise the effectiveness when successful. Loopholes (related to the wording of the

Act) and exemptions suggest that it was not enforced. The Public Health Act of 1875 (which did not apply to London) stated that smoke nuisances should be reduced “as far as practicable”, and leniency was common. The Public Health (London) Act of 1891 introduced equally weak and lenient legislation to the capital, only addressing certain businesses (Thorsheim 2006 pp.113-5). Another example of the power of wording in legislation was the introduction of the term “black” smoke into legislation: it meant that only “black” smoke could be prosecuted as unlawful. It took until 1926 for legislation to address non-black smoke, but, even then, each case needed to receive approval from the Ministry of Health. Thus, into the 1950s, legislation on industrial pollution continued to be heavily flawed (Thorsheim 2006 pp.131).

Furthermore, officials and magistrates in local authorities, who were responsible for prosecution, were reluctant to enforce legislation. The London County Council, which was more interested than other local authorities in reducing emissions but with no immediate power, noted over 9,000 failures to prosecute air pollution infringements between 1892 and 1904. A survey of local health boards across Britain in 1886 gives clues to the problem, as it indicates that nearly one-fifth of the members on the boards were in manufacturing (Thorsheim 2006 pp.115-8). Thus, those that were likely to suffer most from environmental legislation found ways to influence politicians that were drafting legislation and making decisions about it, and to be in positions to minimise their enforcement.

4.3. ‘Adaptation’ to Environmental Problems

As mentioned above, by the mid-nineteenth century, there were a number of solutions to reducing pollution emissions or concentrations. The main solutions were for consumption to become more efficient, switching to less polluting energy sources or exporting the pollution – either by introducing taller chimneys that spread the pollution further or by requiring or encouraging polluting activities to be undertaken further from the city centre. Smoke abatement societies had put pressure on government, and legislation had been introduced. Unfortunately, it was relatively weak and poorly enforced, especially in the long run.

Nonetheless, from the 1890s, the air pollution problem in London (and in other cities) was partially resolved. While still high by twenty-first century standards, air pollution concentration halved over the next fifty years, dropping below $300\mu\text{g}/\text{m}^3$ of Total Suspended Particulate, TSP (see Figure 2). Fouquet (2011b) argued that the main explanation was not fuel switching, as coal consumption and emissions in London continued to increase between 1890 and 1910. It was probably not energy efficiency improvements either. Although the efficiency of many technologies did improve substantially during the second half of the nineteenth century, income and price elasticities of energy service demand appear to have been very high (Fouquet and Pearson 2012, Fouquet 2012). In other words, efficiency improvements, by reducing the implicit costs of energy services, most probably led to large rebound effects, ultimately increasing coal consumption, as Jevons (1865) had predicted.

Instead, the main explanation was the suburbanisation of British cities with the advent of commuter railways. The urbanised area of London increased five-fold between 1841 and 1901, halving the population density, which then declined a further three-

fold between 1901 and 1951 (Demographia 2011). This enabled the population to live less densely and dilute the pollution concentration and population exposure to fall.

This could be seen as a form of ‘adaptation’ to the environmental problem, which led unintentionally to improvements in conditions. But, it was an ‘adaptation’ to a broader series of social and environmental problems, rather than just to air pollution. During the second-half of the nineteenth century, upper-middle class families sought to live away from the crime and sewage, as well as the smoke that engulfed Victorian cities (Luckin 2000). Over the decades, they moved away. The introduction of the Cheap Trains Act of 1883 and a rapid expansion of suburban housing in the 1890s allowed a larger proportion of the population with more modest means to live in the suburbs and commute into the city, leaving the poorest in the centres (Thompson 1982, Jackson 2003, Burnett 1986). In other words, people living in the centre of British cities were bothered by the smoke, and the lower smoke levels were one of the attributes that made moving to the suburbs valuable and desirable. It was not the only (and probably not the strongest) driver for the shift to the suburbs, but was a factor in the process, thus, reflecting a form of ‘adaptation’.

Effectively, the demand for urban improvements increased during the second-half of the nineteenth century, and transport and housing markets reacted, although slowly, to the demand. It took them around fifty years to ‘adapt’ to the demand for improvements in social and environmental quality, and the market outcome was to ‘export’ some of the pollution (i.e., upper and middle class emissions to the suburbs), rather than reduce it. This was not necessarily a desirable long term solution – as was

discovered at the end of the twentieth century, when it continued to be a problem in the form of acid rain and climate change.

5. Markets and Governments before 1950

5.1. Demand for Low Polluting Energy Sources before 1950

As suggested, energy markets were not effective at responding to the demand for environmental improvements. With weak legislation, businesses and households had little incentive to reduce their smoke emissions. Although pollution control was increasingly desired, the free-rider problem hindered the evolution of the market for low polluting energy sources, thus allowing only the relatively wealthy to ‘adapt’ via locational choices.

Despite this market failure of unregulated and unpriced externalities and the more minor role of energy markets in improving pollution concentrations, it is worth examining the extent of the demand to switch to less polluting fuels. That is, some consumers may have been willing to pay for low polluting energy sources, where they could access and use them.

If consumers sought cleaner fuels, they had the option of using anthracite coal, coke, gas and later electricity. Coal quality and uses vary with its geological age and, thus, the carbon content of the coal. It varies from the relatively wet, smoky lignite with a low carbon content and high sulphur content to sub-bituminous to bituminous to steam coal to anthracite. The higher the carbon content, the greater is the energy density of the fuel and the lower its smokiness. The former (lower grades) have

tended to be used for electricity generation; steam coal was often used for train and ship boilers; although consumers have used all types of coal according to their budgets, they tended to prefer higher grades of coal.

Anthracite coal was of particular value for households as it was clean to handle, producing no dust or smoke. “It burns very slowly and never requires poking or attention, except to replenish the stove” (Jevons 1915 p.660). Welsh (steam and anthracite) coal was roughly 20% more expensive than standard coal (Clay and Troesken 2010 p.48). Nevertheless, the doubling of anthracite coal consumption in Britain between 1894 and 1913 - total coal consumption increased 45% (Jevons 1915 p.665) – may have been influenced by the rising demand for smokeless fuels.

Interestingly, British behaviour was still not in-line with other countries. On the continent, the use of stoves had encouraged the consumption of anthracite. For example, it was sold in Paris at £3 per ton – equivalent to £(2000)300 per tonne (Jevons 1915 p.666) – three times the average price of standard coal in Britain. In 1915, more than half of the United Kingdom’s production of anthracite was for export, where as it was around one-third for other forms of coal.

An alternative smokeless fuel to anthracite was coke, often the by-product of creating gas from coal, but also a crucial fuel in certain manufacturing processes, such as in iron smelting. In buildings, it could be used instead of various types of coal but needed different grates, thus, requiring an additional investment.

However, by consuming coke (or gas) much of the problem was shifted to the source of production. Nearby residents “complained that its fumes harmed plants and trees, sullied clothing, tarnished brass and copper, discolour paint, and impaired health... Over time, such localities became occupied almost exclusively by poor and working-class people who rarely possessed sufficient economic, political or legal power to challenge polluters’ activities” (Thorsheim 2002 p.386).

Coke production nearly tripled between 1890 and 1910 (Church 1986). Much of this increase was probably a by-product of the rising demand for gas, discussed below. But, since the iron and steel industries energy consumption only increased by 15% in that period, it is probable that a great deal of households began to use coke for heating and cooking purposes at the turn of the century. Thus, it might have helped to alleviate the pollution problem around the consumers. However, as noted, the nature of coke and gas production implied that neighbourhoods near the production site suffered even more pollution (Thorsheim 2002).

In the late nineteenth century, the threat of electricity capturing a growing share of the lighting market pushed gas companies to try to increase the demand for gas. Their main strategies were to encourage poorer consumers to use gas through the introduction of prepayment meters (known as the penny-in-the-slot), which meant they no longer had to pay for the investment costs of installing gas pipes in their house, and to promote the use of gas for cooking through extensive demonstrations, especially to middle class women (Goodall 1999 pp.80-113, Clenndinning 2004).

Driven by these gas company initiatives to find new markets, there was a rapid uptake of gas cookers from the 1890s. The Gas Light & Coke Company, which supplied two-thirds of London customers, noted that in 1892 only 2% of its customers had gas cookers and, by 1911, 69% had them (Goodall 1999 p.105). In other words, nearly 500,000 households in London (or more than half the homes in London) had gas cookers. An impressive, if slightly more modest growth was seen across the country - in Britain, by 1898, 20% of gas customers, equivalent to 6% of households in the country. This increased to 42% of British gas customers (or roughly 26% of all households) in 1914 (Goodall 1999 p.106). The popularity of gas cookers continued to grow. By 1940, 3.5 million gas cookers had been sold (Goodall 1999 p.107).

Interestingly, there is some evidence about the weakness of local governments in promoting gas cookers and, thus, encouraging a transition to low polluting energy. The coke and gas industry was split between those undertakings in private hands and in the public sector. By 1905, 22% of municipal company customers had gas cookers, while 42% of private company customers had cookers. Over the next ten years, private companies increased the gap – in 1914, 35% of municipal prepayment customers had gas cookers, while 57% of private prepayment customers had cookers (Goodall 1999 p.106). This institutional difference continued for decades: in the 1920s and 1930s, annual gas cooker sales were consistently one-third greater amongst private customers as municipal customers (Goodall 1999 p.107). Private company customers may have been on average wealthier than municipal company customers, thus, being more able to adopt new technologies. Nevertheless, these socio-economic variations may not explain all the difference. This suggests tentatively (although more research is needed) that there may have been a failure of local government to promote

low polluting energy sources at a time when they were desperately needed, and that private enterprise was more effective at promoting the transition.

While gas cookers were competitive and cleaner for the user, and reflected a more modern lifestyle, gas heating was still three times more expensive than anthracite coal (Jevons 1915 p.666). Much of the coal household demand, especially on cold days when the heavy fogs occurred, was not for cooking but for heating. Indeed, total coal consumption (excluding the coal used for gas works) in London still increased by 12% from 1890 to 1910 (see, for instance, Clay and Troesken 2010 p.71) - implying that total emissions rose, as well. Nevertheless, it is important to note that the increase in consumption of low polluting energy sources may have helped avoid a worse “business-as-usual” counterfactual. After all, between 1890 and 1910, national population increased 19%, per capita GDP 13%, and coal prices stayed relatively constant (Fouquet 2008). Thus, given the probable high income and price elasticities at the turn of century (Fouquet and Pearson 2012, Fouquet 2012), coal consumption and emissions might have been expected to increase substantially more than 12%.

Later, in the 1930s, electric cookers were seen as the height of modernity and their use took-off, increasing from 210,000 in 1932 to 1.5 million in 1938 (Bowden 1988 p.44). Part of this increase was driven by growing access to electricity. In 1932, only 31% of the housing stock had access to electricity; by 1938, 65% were wired (Bowden 1988 p.44). Nevertheless, the proportion of wired-homes using electric cookers rose from 5% to 17% (or 1.5% of all homes to 11%) in that time. Marketing efforts, including deferred payments and the creation of a modern image for electric appliances, were important drivers of the growth (Bowden 1988, Hannah 1982). Also,

rising incomes helped boost demand, as electric cookers were seen as more advanced than gas cookers - given that only wealthier households were able to afford to use electric cookers, they were probably substituting away from gas (rather coal and its derivatives). During the 1930s, electricity prices fell 35%, while gas prices increased (Fouquet 2011a). Thus, this new demand for a lower polluting energy source than coal was driven probably more by economic forces, convenience and status, than responding to a demand for environmental quality.

5.2. The Evolution of Government's Approach to Environmental Problems

Historically, the British government had tended to avoid involvement in industrial activity or meddling in domestic affairs. The latter would have been interpreted as an invasion of personal liberties, and the former was thought appropriate only when absolutely necessary. The dominant economic ideology within government before the twentieth century was relatively laissez faire within Britain, apart from the growth of fiscal intervention to support the public budget and debt. This ideology, in part, reflected those in power, landed gentry and increasingly entrepreneurs and merchants, who benefitted most from the lack of government involvement in economic affairs. Thus, one of the main perceived functions of government was to protect private property, but not to interfere in its use (Thorsheim 2006 p.110).

However, the role of government began to increase from the 1830s, as it was seen that if property was damaged without consent by others' behaviour, there might be grounds for government intervention. Traditionally, victims of pollution had the right to seek compensation for the damage caused by the perpetrator, either in voluntary

Coasian negotiations (i.e., through bargaining polluter and victim can achieve a socially desirable outcome) or through the courts. However, the expansion and increasing concentration of industrial activities made it difficult to undertake such costly negotiations and prosecution. “Early environmental legislation was ... justified by the argument that state intervention was necessary in cases where it was impractical for individuals to identify and hold responsible the particular firms that were causing harm to property”, such as the Alkali Act of 1863 (Thorsheim 2006 p.111).

Another important change in the role of government followed the First World War. The government’s strategic interests led it to become heavily involved in many aspects of economic and social affairs that were previously seen as beyond its remit. It also started to develop a more analytical approach to problems. This included its eventual role in directing energy policy to reduce air pollution (Thorsheim 2006 p.129).

With this changing role and greater analysis of government came an increased need for expert advice. Before the mid-nineteenth century, science had often been seen as unimportant, and not directly relevant to public affairs. It started to be used to advise in public health issues, such as its use for evidence by the Select Committee on Smoke Prevention in 1843. Nevertheless, scientists’ active involvement in directing policy was much slower, and only became common in the twentieth century (Thorsheim 2006 p.129-30). Without these major changes in political involvement and understanding of problems, it is unlikely that government would have been able

to react to the growing demand for environmental quality (Ashby and Anderson 1981).

6. The Big Smog and the Clean Air Act

6.1. The Big Smog and High Polluting Energy Sources

Conditions by the mid-twentieth century were much improved, compared with fifty years earlier. Average air pollution concentration had fallen below $200\mu\text{g}/\text{m}^3$ (see Figure 2). Foggy days were occasional and shocking, rather than part of everyday life. Severe air pollution was less acceptable then, than it had been in the nineteenth century. One could argue that, perhaps as a result of rising income or greater awareness of the health impacts, the demand for environmental quality had increased considerably by the mid-twentieth century.

Starting on 5th December 1952, cold and windless weather patterns trapped smoke over London for almost one week. The cold weather increased the number of domestic fires; the resulting smoke stopped sunlight from providing natural heating, thus, requiring more coal to be burnt. The intense fog led to many respiratory problems, especially amongst the young, the weak and the aged.

The Big Smog shocked the nation. The ministry of health downplayed the event, blaming influenza and already weak victims – it initially suggested that 2,851 people died from the fog. Its attitude was to feel that the fogs had been happening for centuries and it had little role to play. In the months following the event, the government was severely criticised for its indifference, despite some warning that this

could happen again. Seven months later, the Beaver Committee was formed to investigate the event - the official number of deaths was eventually placed at 3,000-4,000 (Thorsheim 2006 p.163-6). However, one recent study of the event estimated that the air pollution may have led to an additional 12,000 deaths - including long term effects, yet excluding those associated with influenza and the cold (Bell et al 2004).

One potential aggravating factor was the type of coal used. In the winters of 1946-7 and 1950-1, the coal industry, run as a monopoly by the National Coal Board, faced major crises. Unable to supply enough coal for the demand, it began to ration. In 1951, trying to prioritise needs for electricity supply, it limited industrial consumption to 85% of normal use, it demanded that 3,000 passenger railway services be cancelled, and it rationed most households to 8cwt (roughly 400kg), although in Southern England, they were limited to 6cwt (about 300kg) of coal for the months of January and February (Jackson 1974 p.73).

The National Coal Board had been criticised for not supplying enough fuel to heat homes. It planned to keep rationing until 1958. However, prior to the season of cold weather, it organized an intensive advertisement campaign to encourage the use of “nutty slack” coal for domestic heating and, on the 1st December 1952, it would stop rationing its use. Nutty slack was a mix of small lumps of coal and dust. It was dirty to handle, produced a lot more smoke, but it was cheaper. It was 20 shilling per ton (i.e., 30%) cheaper than standard coal (Thorsheim 2006 p.161-2). Although it is difficult to find estimates of household consumption, in five years, between 1948 and

1953, the consumption of “slack” coal increased 25% and increased its share of total UK coal consumption from 34% to 39% (Ministry of Power 1961 p.72).

To minimise or avoid future similar episodes, the Beaver Committee highlighted the need to warn the public, advise vulnerable populations and maintain the use of smokeless fuels. The final Beaver Committee report in late 1954 proposed the creation of a Clean Air Act which included domestic, as well as industrial, pollution (Brimblecombe 2006).

6.2. The Clean Air Act and the Shift to Low Polluting Energy Sources

The Clean Air Act specified “black” areas, where the problem was most acute and smoke control programmes were most important. All areas in Greater London were designated as “black” areas and, generally, required controls. In the North West of England, 95 of the 151 areas were either “black” and/or to be controlled (Scarrow 1972 p.264).

In controlled areas, smoke emitting fuels, principally coal, were banned and smokeless fuels needed to be used for heating instead. Until then, the main cause of local air pollution, households, had remained an uncomfortable issue - traditionally, the British had had an attachment to inefficient coal-burning open fires, rather than stoves as used on the continent (Rudge 2012). The Clean Air Act required the conversion of domestic fires where pollution was a problem. It also involved inspection beforehand to identify the extent of the conversion needed and then afterwards to ensure the conversion was done properly.

A number of factors influenced a borough's progress towards meeting the requirements of the Clean Air Act of 1956. These were a borough's wealth, a perceived need for improvement in air quality and whether it was a mining area. First, the conversions and the inspections were very costly for local authorities. Wealthy "black" areas consistently made better progress towards meeting the targets for compliance with the Clean Air Act than poorer areas (Scarrows 1972 p.267). Second, the nine boroughs with the highest rates of bronchitis mortality in Britain had a median progress (towards compliance with the legislation) of 46.3%, while the boroughs with the lowest rates had a progress of 19.4% (Scarrows 1972 p.277). Finally, mining areas tended to be reluctant to introduce changes as this was a politically sensitive issue.

It is valuable to consider the environmental and health impact of the Clean Air Act. From 1958 to 1965, smoke concentrations improved greatly – in London sites, a 60% reduction, and in other sites, 27.5% (Scarrows 1972 p.272). Crucially, by the mid-1960s, weekly mortality and illness rates stopped varying with air pollution concentration, as they had before 1960 (Scarrows 1972 p.273). Another of the noticeable effects of better air quality was greater sunshine. During the months of November, December and January in the 1960s, inner city London had 55% more sunshine than in the same months between 1930 and 1960 (Scarrows 1972 p.273). Interestingly, this greater sunshine probably helped reduce energy consumption associated with space heating and lighting.

However, the improvements that were observed in the early 1960s may have been the acceleration of a larger trend. Air pollution concentrations had been falling since 1900 (see Figure 2). Similarly, energy consumption patterns in the second half of the twentieth century were also changing. “The new affluence ... in postwar Britain ... resulted in a demand for higher heating standards, viz., the cleaner systems which solid smokeless fuels introduced, and the labor-free, automatic, multiroom, and total-building heating systems associated with electricity, gas, and oil.” (Scarrow 1972 p.275). A survey of households in 1961 found that space and higher standards of heating were the most important features to improve in homes (Scarrow 1972 p.275).

In addition to rising income and changing consumer preferences, energy supply companies played an important role in first delaying and then accelerating the transition. After the Clean Air Act was passed, the National Coal Board introduced an advertisement campaign promoting the “cosy coal fire” to discourage a shift to oil, gas or electricity. Local coal merchants also tried to oppose and delay local authority efforts to comply with the Clean Air Act (Scarrow 1972 p.277).

However, gas manufacturers seeking the cheapest production fuel heavily affected the market for smokeless fuels. Traditionally, they had used coal to produce gas. As a by-product, they also produced coke, which could be sold as a smokeless fuel. However, in the late 1950s, they found that oil was cheaper to produce gas. This switch led to a shortage of coke, officially announced in 1963. The National Coal Board failed to produce enough coke and other smokeless fuels to meet the demand, encouraging a switch to other non-solid fuels (Scarrow 1972 p.277).

Another important factor was the slum clearance programmes introduced from the mid-1950s. Between 1955 and 1970, 733,000 houses were demolished in London and other Northern “black” areas - equivalent to one-sixth of the homes in the highly polluted areas in 1970 (Scarrow 1972 p.276). When these homes were replaced, the new ones usually included central-heating systems that rarely depended directly on coal.

Smokeless solid fuels enabled households and other buildings to comply with the legislation while keeping the conventional way of heating a building. Indeed, in 1950, before legislation was introduced, nearly 40% of the heating demand in London was met by other solid fuels, which were mostly smokeless. In other words, many consumers had already been willing to pay for the smokeless fuels before the Big Smog and the Clean Air Act. It is difficult to identify the premium they paid for smokeless fuels, but they were no doubt more expensive than standard coal. Yet, after the Clean Act, the share of coal and other solid fuels in London declined from 71% in 1950 to 24% in 1970 (see Table 1).

In the 1960s, the biggest substitution was to oil – meeting nearly half of the heating consumption in London. However, the discovery of natural gas in the North Sea and the Oil Shocks led consumers to switch to gas – from 26% in 1970 to 65% in 1980 and up to 85% in 1990 (Fouquet 2008).

7. The Dash for Gas

The tendency to export pollution, either by suburbanising British cities or creating smoke-less zones and higher industrial chimneys, meant that emissions were not always discouraged. Nevertheless, from the mid-twentieth century, as the British economy moved away from heavy industries and made the transition from coal towards petroleum (see Figure 1), emissions did decline.

Nevertheless, coal consumption was crucial for power generation and was still responsible for sulphur dioxide emissions that were associated with acid rain. Due to prevailing winds, acid deposition occurred in the Highlands of Scotland and in Scandinavia, increasing acidity in lakes and forests, killing certain plants and animals, and corroding buildings.

In the 1980s, much of the pressure to set target reductions in emissions came from other countries. This included the Scandinavians (who were concerned about British acid rain harming their lakes and forests) and the West Germans (who had introduced Flue Gas Desulphurisation units on their coal-burning power stations to reduce emissions, raising the price of generating electricity and, thus, reducing the competitiveness of their products). This international pressure led to the creation of an international convention. The Convention on Long Range Transboundary Air Pollution (LRTAP) was proposed in Geneva in 1979; the United Kingdom signed in 1982. This set an international framework for agreeing to reduction protocols. In 1985, the first protocol proposed was to reduce sulphur dioxide by 30% of the 1980 level by 1993. The British government did not sign (Fouquet 1993).

Within the European Community, pressure was mounting for the British to accept targets. After many rounds of negotiation to introduce the Large Combustion Plant Directive, in 1988, the United Kingdom agreed to reduce its electricity generation and large industrial SO₂ emissions by 20% of the 1980 level by 1993 and by 60% of the 1980 level by 2003. This change of stance by the British coincided with plans to privatise the electricity supply industry: thus, the costs of reducing future emissions would not be incurred by the public sector (Fouquet 1993).

Indeed, a shift away from coal was achieved – from 75% of the total inputs in 1981 to 65% of the total in 1991 to 28% of the total in 2000. Between 1981 and 1991, nuclear power rose from 15% to 23% of the total and, between 1991 and 2000, natural gas increased from less than 1% of the total to 38% (Fouquet 2008). This shift has been mainly due to successive United Kingdom government's support for nuclear power until the mid 1990s and to the privatisation and liberalisation of the electricity supply industry which encouraged generators to use CCGT (Combined Cycle Gas Turbine) plants, because of lower duration and costs of installation, of the incumbents' desire to create over-capacity discouraging market entry and of the regulator's desire to encourage competition through independent power producers (Newbery 1994, Pearson and Watson 2012).

8. Insights for Meeting the Demand for Climate Stability

Throughout history, citizens have been harmed by air pollution resulting from fuel combustion. The episodes discussed in this paper led to heightened calls for improvements in air quality. They tended to coincide with periods of economic

growth. This implies, first, that the damage increased due to greater consumption and pollution, possibly with rising marginal external costs or benefits of abatement. Second, affluence enabled Britain's citizens to be concerned with more than their basic economic needs. Whether John Evelyn in the seventeenth century, the Smoke Abatement Societies in the nineteenth century or an outraged public in the mid-twentieth century, demand has put pressure on governments to introduce legislation. Despite it having been a general period of low air pollution by historical (though not today's) standards, the episode with the strongest demand for improvements (see Table 2) was after the Big Smog of 1952 when the death toll in London was particularly shocking and scientists could attribute these deaths to poor air quality, and a growing range of substitute fuels and heating technologies was available.

It has been proposed that the basis for climate policy lies in a domestic demand for climate policy rather than in a multilateral agreement or a supranational command (Tol 2012). There is evidence that some people in certain countries value climate stabilisation and are willing to pay to reduce greenhouse gas emissions (Li et al. 2004, Cameron 2005, Berrens et al. 2006, Lee and Cameron 2008, Brouwer et al 2008, Mackerron et al 2009, Cai et al. 2010, Löschel 2010, Diedrich and Goeschl 2011). However, there is little evidence of strong support for major and costly abatement on the scale that occurred in the 1950s (Fouquet 2011a).

Despite this growing literature on the relationships between the demand for climate stability and key variables, such as cultural factors, income, or potential damages, the exact causal mechanisms are not clearly understood. The evidence in this paper suggests that, while rising income does appear to be associated with greater concern,

demand is likely to be greatest in periods of economic prosperity, rather than in the depths of a recession. In addition, concurring with Lee and Cameron (2008), demand grows as the perceived damages rise. Also, based on these historical experiences, the demand for climate stability will probably increase as a result of extreme and shocking events that (most will agree) can be attributed (with a high degree of confidence) to climate change (Kingdon 1995).

However, even with a major demand for improvements, it is far from certain legislation will be introduced. The smoke abatement movement in the Victorian era faced a clear example of government failure because of politicians' belief that legislation would harm business and industry. However, estimates of the value of health damages indicate that the benefits of reductions in air pollution would have significantly outweighed the costs during the second half of the nineteenth century (Fouquet 2011b). By comparing the average external costs with the average benefits of consumption (using price as a proxy), certainly by 1850, British coal consumption was socially sub-optimal (i.e., too high). Despite the availability of solutions to reduce emissions and concentrations in the second-half of the nineteenth century, suggesting that more stringent (enforced) environmental legislation would have generated significant social net benefits, demands to regulate were met with weak legislation and limited enforcement. This lack of effective and enforceable legislation was a clear example of government failure, and it took around one hundred years, and the introduction of the Clean Air Act of 1956, to introduce the necessary legislation.

Clearly, pressure groups for and against climate action are seeking to sway the public and, particularly, politicians (Boyer and Laffont 1999). The strongest argument

against abatement is still the fear of the economic costs of abatement, either direct or associated with an economy's competitiveness. Thus, overcoming the perceived economic damage from legislations is still the most likely way to sway politicians (Shogren 1998).

Furthermore, just like in Victorian Britain, although legislation is being introduced, it is failing to address household behaviour, and their emissions associated with residential and transport energy consumption. In democracies, the politician's fear of angering voters weakens the effectiveness of most climate policies. It also implies that politicians believe the public's demand for climate stability to be especially fragile.

So, even with effective legislation introduced, for it to be sustained (i.e., enforced and not revoked by future governments), it must be of limited cost to polluters, and pro-legislation pressure groups must continue to maintain their pressures on politicians. For demand to be sustained, it seems likely to either require a series of shocking events, or a wide scale change in value systems that can support (and in lifestyles that can accommodate) long term political pressure. Indeed, the opposite seems more likely – those that are suffering from the legislation are willing to pay for the legislation to not be enforced or to be rejected by successive governments. Also, the lags involved in markets adjusting to new incentives imply that if governments introduce legislation, those seeking improvements may have to wait a decade or more to assess the success of these policies.

Although not directly about energy-related air pollution, the Alkali Act of 1863 (as does the Montreal Protocol) shows that environmental legislation can be effective if

the victims are sufficiently influential, the polluters are a clearly defined and observable group, relatively cheap solutions are available and equipment exists for monitoring pollution levels. Under such circumstances, manufacturers can be open to reducing emissions and government willing to introduce legislation. This also suggests that legislation targeted at specific groups may be more effective and sustainable than when covering a heterogeneous array of polluters.

Another lesson is how the demand for environmental improvements is being met. In a number of instances, the reaction was first containment of the problem, then dispersion of (or exporting) the problem. Although countries are exporting their home production of carbon dioxide emissions, such as through the importing of goods now produced elsewhere, this is even less of a solution for a global pollutant. Similarly, but without a clear historical precedent, carbon sequestration, in its various guises, offers another approach to dealing with emissions without actually reducing them. This approach is, therefore, potentially attractive to many consumers as it does not directly affect lifestyles or work; although, at present, the costs of carbon capture are expensive (and little is known about its public acceptability).

A further solution was and is to promote energy efficiency improvements. Markets have an incentive to seek efficiency improvements in order to provide energy services at lower prices, and have been especially successful over the last two hundred years (Fouquet 2011a). Thus, governments can aid markets to work towards further energy efficiency improvements. Unfortunately, especially in developing countries, rebound effects may eat-up some of the savings and, in the longer run, rising income levels are

likely to lead to more demand for energy services and energy (Fouquet and Pearson 2012, Fouquet 2012). So, efficiency measures cannot solve the problem on their own.

Transitions to low polluting energy sources have been and are clear solutions to specific environmental problems. Independently of governments, markets can seek the energy transition option (Fouquet 2010). In the case of low-polluting energy transitions, there are definitely fewer examples, but the past switches to gas and electric cookers hint at the possibility that markets might take the lead in certain sectors and services. This is particularly of interest when the niche demand leads to declining prices through a process of economies of scale and learning by doing. As section 5.1 showed, a niche non-free-riding demand can exist for low carbon energy sources and technologies. This demand will be greater if the sources and technologies have desirable characteristics that fossil fuels and their related equipment do not have. One powerful driver of demand in the past, as seen in the demands for gas and electric cookers, has been social status. Thus, if low carbon sources and technologies can be seen as status-enhancing, they may achieve an important niche demand. If this niche demand develops, and producers can achieve economies of scale, then the prices might become competitive with fossil fuels. In this case, markets could drive part of the transition to a low carbon economy.

More probably, though, government will need to help create the demand for these energy sources, especially when the price of the low-carbon option is more expensive. Transitions often require the discovery of new solutions for many different sectors and services, the transformation of energy systems (which are complex), and the decline of energy industries and technologies that are represented by powerful

pressure groups (Fouquet 2010). Thus, given the scale of the change and the time they take to unfold, governments tend to be reluctant to push for energy transitions in the first instance. Furthermore, transitions have and may create new environmental problems (such as coke and town gas, petroleum products, nuclear power or even certain renewable energy sources). Nevertheless, the experience of the Clean Air Act of 1956 shows that, with sufficient pressure and resolve, governments can initiate transitions to low polluting energy sources.

Inevitably, the direction taken to meet the demand for environmental improvement reflects a tension between political and economic forces, and not always the most socially beneficial course of action is followed. The direction chosen to achieve climate stability will reflect the costs of abatement associated with low energy sources and technologies, efficiency improvements, carbon sequestration and geo-engineering, and the influence of the pressure groups representing the various options.

Ultimately, the broader lessons are more subtle than the standard textbook view proposing that markets fail and governments have to intervene, or even that both tend to fail. These experiences suggest that both markets and government (perhaps together) can eventually play a role in meeting environmental concerns. First, governments tend not to prioritise environmental legislation. They only introduce effective, enforced and sustained legislation when the conditions are ideal or the pressure is unavoidable. The Alkali Act of 1863 and the Clean Air Act of 1956 show that broader legislation can be effective – but, as in the latter case, it may come one hundred years later than was probably socially optimal (Fouquet 2011b).

Second, viewed over a century or more, markets may also ‘adapt’ to environmental demands (such as the shift to suburbia at the end of the nineteenth century, the demand for gas and electric cookers in the early twentieth century, and the dash for gas). However, apart for the latter case, they tend to do so very slowly and not necessarily in a socially optimal way – after all, they seek the cheapest or most profitable solution. Thus, it would seem unwise to wait for markets on their own to solve environmental problems.

Finally, crucial to the outcome of the episodes reviewed was the evolution of ideology, of government attitudes towards intervention and of the relationship between the market and the state. It would be difficult to identify trends in the forces over the next century. Nevertheless, they will evolve, such as perhaps new beliefs about our relationship with nature or the potential globalisation of markets and governments, and will play an important role in determining any transition to a low carbon economy.

9. Conclusion

The purpose of this paper was to understand the long run demand for energy-related environmental quality, its influence on legislation and on the substitution to low polluting energy sources. Although it did not focus exclusively on energy transitions, it sought to present some of the forces that drive a transition to low polluting energy sources.

The paper presented a review of five cases of historical environmental demand: the seventeenth century, the Victorian era, and the early-, mid and late-1900s. Each experience was quite distinct and offered insights about how the demands were (or were not) met. It was proposed that these insights from a long-term historical perspective on market developments and particularly environmental legislation are useful for understanding the long run process and barriers to meeting demands for climate stability, possibly through a transition to low carbon energy sources.

Gathering and using evidence is fraught with difficulty, especially as the processes under observation can unfold over different time periods – demand can form in days; legislation can take months to introduce; but, markets can take years, decades or even centuries to change. In addition, historical data is inevitably inconsistent and frequently inaccurate.

Furthermore, to present these episodes, it may have failed to emphasise or even identify certain important determinants of the process. In particular, a combination of factors and the co-evolution of a number of institutions and organisations need to occur in parallel and underlie these changes. Indeed, there were many economic, social, political and cultural transformations that were happening simultaneously and had important bearings on the episodes discussed. Space was the limiting factor in drawing-on these important aspects of change, which should be integrated more fully in future work on this topic. A good complement to the current paper is Turnheim and Geels (2012), which analyses the decline of the coal industry through a co-evolutionary lens.

Finally, there are considerable differences between the past and the future. One obvious difference is in the different characteristics of the demand for improvements in air pollution and for climate stability, as well as the related legislative issues and energy markets. For instance, the latter addresses a global stock pollutant, with the potential for international spillovers of ideas and technologies to address the problem. Also, the demand presented in these historical case studies was for existing environmental impacts, where as climate stability relates to future damages.

Despite the limitations of the present paper, it is proposed that the insights discussed above are valuable. It is possible that low carbon energy sources and technologies will become cheaper than fossil fuels, in which case markets can drive the transition to low polluting energy sources. This may occur first in some countries where renewable energy resources are unusually abundant and cheap. Alternatively, it might occur in a country where consumers refuse to free-ride and demand low polluting energy. Then again, if the markets do not drive the transition, governments will need to push it, and this cannot be expected without strong and sustained demand for climate stability – as in Germany, where renewables have been deemed worthy of significant state incentives. Yet, while demand is a prerequisite, it is not enough. It must also be spearheaded by strong, creative and sustained pressure groups (i.e., powerful lobbying and the weakening of the counter-lobby) to introduce legislation, to enforce it and to avoid it being overturned by future governments.

At present, however, it is highly doubtful whether, in any country, there exists a stable demand for climate stability large or powerful enough to drive the long run changes necessary to achieve a transition to a low carbon economy. Thus, the author of this

paper wonders whether history might not repeat itself, and, through a combination of markets and governments, mostly failing, but at times responding to a weak demand, climate stability will eventually be achieved, at the very least, one hundred years later than was socially optimal.

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Table 1. Non-Electric Energy Use for Heating in London, 1950-2000

	1950	1960	1970	1980	1990	2000
Oil	10.7%	26.7%	46.9%	27.6%	14.3%	4.8%
Gas	17.9%	16.7%	26.6%	65.5%	85.7%	95.2%
Coal	32.1%	16.7%	3.1%	0.0%	0.0%	0.0%
Other solid fuels	39.3%	36.7%	21.9%	6.9%	0.0%	0.0%

Source: GLA (2002) p.21.

Note: Electricity is not included because of the difficulty of separating consumption between heating and other services – its inclusion would only increase the decline in solid fuels.

Table 2. Summary of Historical Demand, Legislation and Substitution to Low Polluting Energy Sources

	Demand/ Lobbying	Governmental Support	Legislation Introduced	Legislation Effective Enforced and Sustained	Legislation on Energy	Substitution to Low Polluting Energy
1660s	Weak/ Influential	Yes Not Priority	No	No	No	No
1840s- 1890s	Medium/ Modest	Reluctantly Not Priority	Yes	No	No	No
1890s- 1930s	Medium/ Modest	Reluctantly	Yes	No	No	Some
1950s- 1960s	Strong/ Influential	Reluctantly Priority	Yes	Yes	Yes	Yes
1980s- 1990s	Weak/ Influential	Reluctantly Not Priority	No	No	No	Yes
2000s- 2010s	Medium/ Influential	Yes	Yes	?	Yes	Some

Note: This table summarises the experiences discussed above, with the first five rows reflecting the five sections 3-7, respectively. The classifications are based on the authors interpretation of the experiences.